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Not-for-profit supply chains for product take-back: practices, unique logistical challenges and directions for new research

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The extant literature in the field of reverse logistics has paid scant attention to take-back supply chains that are not aimed at making a profit. We attempt to flesh out this knowledge by highlighting how the processes of core acquisition, remanufacturing and marketing segmentation carried out in not-for-profit supply chains differ from those of for-profit ones. Drawing on the observed dissimilarities, we establish that the former have logistical and marketing challenges that are unique to them, which have not been examined in prior research, e.g. Donations being the main source of core, there is a need to maximise the volume and quality of products that are returned as donations. We conclude this paper by proposing questions for future research, e.g. How to improve the collection of core when no direct financial incentives are offered? What are the company (donor) specific determinants, e.g. size and industry, moderating the quality of donations?

Keywords: E-waste, Voluntary Sector, Remanufacturing, Not-for-profit Organisations, Sustainable Supply Chains and Reverse Logistics.

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1. Introduction

For many years companies have recovered a proportion of the products they sell. Returned products are sometimes recycled, a process whereby their valuable raw materials are collected, e.g. silver and gold are extracted from mobile phones (Umicore 2011). They are also remanufactured, the process in which after collected, products are inspected, sometimes upgraded and brought to the same functional and (whenever possible) cosmetic conditions of their new counterparts (Thierry et al. 1995). These processes are mainly driven by economic and legal reasons in for-profit supply chains.

At an increasing number of cases, however, products are also recycled and remanufactured with social and environmental objectives in mind. Non-for-profit organisations such as Create UK and Arc Direct, based respectively in Liverpool and Belfast, have been set up to address the issue of electronic waste (e-waste), while providing much needed training and jobs in deprived communities. Over the past decade or so, organisations such as these two have refurbished thousands of products and trained hundreds of long-term unemployed. Consumers have also increasingly engaged with not-for-profit organisations and supported their efforts by, for instance, donating used items and volunteering (Curran and Williams 2010).

In this paper, we refer to the supply chains that are not aimed exclusively at making a profit as Not-for-profit Supply Chains, or shortly, NSCs (in Section 2 we further elaborate on what precisely constitutes a NSC). Although NSCs have gathered a lot of momentum over the past decades, our understanding on them is rather restricted. In light of that, we contribute to the extant literature on reverse logistics and not-for-profit sector by: (i) documenting current industry practices. In other words, we document how the processes of core sourcing (the sourcing of defective and used items that are collected to be recycled or remanufactured); testing and remanufacturing; and marketing segmentation are carried out in the context of NSCs. More important, we elaborate on how dissimilar these phases are when executed in NSCs, as opposed to for-profit ones. We show that some of the challenges NSCs face are unique, and have not been fully addressed in literature, and (ii) proposing new avenues of research based on these dissimilarities. Grounded on the differences that exist between NSCs and for-profit supply chains, we propose new research questions that are of greater relevance to NSCs.

We focus on the supply chains that recover personal computers as the market for remanufactured computers is perhaps one of the most important for remanufacturers, and because for-profit and not-for-profit organisations alike are involved (Quariguasi Frota Neto and Bloemhof 2011). In the UK alone, we estimate that hundreds of independent remanufactures/resellers currently repair and trade personal computers (source: Interview with large independent remanufacturer). Microsoft and Gartner estimated that millions of personal computers are returned to the market as refurbished items (Microsoft 2007).

The main findings of this paper are as follows. With respect to the process of core acquisition, we observed that obtaining quality core is challenging for for-profit and not-for-profit organisation alike. The dissimilarities, which are the focus of this paper, were pronouncedly evident when we examined the incentives given to consumers to obtain used products. Not-for-profit organisations rely on donations heavily and, for the most part, do not offer the same financial incentives as manufacturers and independent remanufactures. Concerning testing and remanufacturing, the main dissimilarities lie on the workforce employed. Volunteers composing a considerable proportion of the workforce, the operational capacity for remanufacturing may fluctuate over time. More important, some not-for-profit organisations have the training of the workforce and the provision of temporary jobs to the long-term unemployed as chief goals. Concerning the marketing of the remanufactured products, we have documented the following dissimilarities: NSCs

aim at attaining a number of different objectives, e.g. providing IT training and computers in schools. Unsurprisingly, marketing decisions are not aimed at profit maximisation only - Social and environmental considerations are also taken into account.

This article is organised as follows. In Section 2 we review the relevant literature and present the main characteristics of for-profit supply chains. In Section 3 the process of data collection is outlined. In Section 4 we present, based on our unique dataset, the main characteristics of NSCs, and discuss the differences between them and for-profit supply chains for product recovery. In Section 5, we outline the managerial implications of our findings. In Section 6, we propose new avenues of research. In Section 7, the main findings are summarised.

2. Literature review on reverse chains

2.1. *A review on non-for-profit supply chains (NSCs)*

Various organisations are involved in dealing with returned products, e.g. manufacturers (e.g. Dell), charities (e.g. AgeUK, The Price's Trust), social enterprises (Dot-Communications), for-profit remanufacturers (e.g. ReCellular) and software companies (e.g. Apple computers, Microsoft). As recovery supply chains are normally constituted by various players, e.g. recyclers, remanufacturers and final receivers of the products being remanufactured (Bernon and Cullen 2007), and they can be either for-profit or non-for-profit organisations, classifying supply chains in terms of their profit orientation is not simple.¹ Prior research has alluded to such arrangements, in which not-for-profit and for-profit organisations work closely together to achieve complementary goals (Austin 2000; Harris 2012), but a widely accepted definition of what constitutes a not-for-profit supply chain is yet to be formulated. The classification used in this paper is based on the profit orientation of the organisation receiving the returned products (i.e. the actor in which the supply chain starts) - thus, a supply chain for product recovery is said to be a NSC when the collector is an organisation whose main goal is not to profit from the supply chain, i.e. to profit from the sales of the remanufactured products. Our classification is based on the actor in a supply chain for product recovery who most commonly plays the biggest part in orchestrating it, i.e. the collector/remanufacturer.²

2.2. *A review on for-profit supply chains*

Literature on supply chains for product recovery has focused mainly on for-profit supply chains, and NSCs have received little notice. There are only a handful of studies that have NSCs as focus, and they are mostly case studies. Lounsbury, Venstreca, and Hirsch (2003) noted that recycling has started with not-for-profit organisations in the 70's and 80's before becoming a mainstream business; Rao (2004) discussed an example of cooperation in product recovery between not-for-profit and for-profit organisations in Thailand; Kumar and Malegeant (2006) presented a case study of a successful cooperation between profit and not-for-profit organisations in the shoe industry and advocated that such collaborations could be beneficial for both parties and the environment. In the sole paper (that we are aware of) addressing the issues faced by NSCs analytically, Reyes and Meade (2006) proposed an analytical model to improve responsiveness of not-for-profit organisations.

The work that is more closely related to this paper is the paper by Curran and Williams (2010), which examines the role played by furniture and appliances re-use organisations in England and Wales. In this paper, the authors examine how the supply chain of re-use organisations are organised e.g. how products are collected, the treatment they receive,

and how they are placed back into the market. Although some of our findings overlap with those of Curran and Williams (2010), as we point out throughout the rest of the paper, our work departs from it as : (i) based on the literature that has developed in the field of Operations Management and Operations Research on product take-back, we compare for-profit and not-for-profit organisations and (ii) outline the main logistics issues/questions that arise from such differences and contrast those with the existing body of literature on reverse logistics (iii) use this information to propose new areas for future research.

In the rest of this section, we discuss the research that has focused on for-profit supply chains, because, as previously remarked, it comprises roughly the totality of the work done on this stream of research.

2.2.1. Core acquisition

Core acquisition is a sometimes considered the most important step in the remanufacturing process, and core of acceptable/high quality figures among the most important conditions for economically viable product take-back supply chains (Guide, Teunter, and Van Wassenhove 2003). Prior literature in core acquisition that developed within the field of Operations Management is well developed, albeit mostly focused on modelling. Concerning pricing decisions for the acquisition of core, Guide, Teunter, and Van Wassenhove (2003) argued that adopting quality-dependent acquisition prices can increase quantity and quality of core and showed how such strategy should be employed to mobile phones; Galbreth and Blackburn (2006) derived an optimal acquisition (and sorting) strategy for remanufacturers buying cores from brokers. Table 1 summarises briefly the research that has been carried out on core acquisition.

Table 1. Summary of the literature on core acquisition in supply chains for product take-back.

Questions	Methodology	Literature
What is the optimal price to pay for core and how much core must be purchased? What are the quantities if quality levels are considered?	Mathematical modelling	Guide, Teunter, and Van Wassenhove (2001), Guide, Harrison, and Van Wassenhove (2003), Guide, Teunter, and Van Wassenhove (2003), Guide, Harrison, and Van Wassenhove (2003), Savaskan (2004), Bakal and Akcali (2006), Fegurson and Toktay (2006), Galbreth and Blackburn (2006), Mukhopadhyay and Ma (2009), Galbreth and Blackburn (2010), Loomba and Nakashima (2012), Teunter and Flapper (2011), Van Wassenhove and Zikopoulos (2010) and Loomba and Nakashima (2012).
From a financial point of view, how attractive is sorting? What is the value of sorting ? Where should acquired core be inspected and sorted?	Mathematical modelling	Rudi, Pike, and Sporsheim (2000), Galbreth and Blackburn (2006) and Zikopoulos and Tagaras (2008).
From which collection sites should a remanufacturer source their core from?	Mathematical modelling	Zikopoulos and Tagaras (2007)
What is the value of information in core acquisition operations?	Mathematical modelling	Debo, Toktay, and Van Wassenhove (2005) and Ferrer, Heath, and Dew (2011).

Sorting and inspection is another area that has received a lot of attention. Sorting is the activity whereby products are classified according to their quality. The main decisions on sorting that have been addressed in the reverse logistics literature are: whether or not to carry it out and where it should take place (e.g. in the collection points or after they have been transported to the remanufacturing facilities).

Other various issues related to core acquisition that have been investigated in prior research are: from which collection points should remanufactures collect from? and what

is the value of information in the context of supply chains for product recovery? (Tagaras and Zikopoulos 2008; Ferrer, Heath, and Dew 2011).

2.2.2. *Testing & remanufacturing decisions (and inventory control)*

Testing and remanufacturing are the steps that follow collection in a product take-back supply chain (Guide, Teunter, and Van Wassenhove 2001). These two phases have also received a great deal of consideration in past research. Examples of questions that have been already examined include: Once core has been collected, which items should be re-manufactured? and when to remanufacture them?

Normally these decisions are examined in the broader context of inventory management. Van der Laan et al. (1999) compared two different planning control mechanisms in which products are either remanufactured at arrival or as most convenient, DeCroix, Song, and Zipkin (2005) and DeCroix and Zipkin (2005) examined the problem of inventory management in the context of remanufacturing operations too, and studied the case where demand could be negative (i.e. product returns). They showed how the complexity of inventory control increases when returns are allowed, and developed heuristics to deal with such scenario. As it is the case for product acquisition, past research has developed under the paradigm of cost minimisation or profit maximisation, i.e. minimise inventory costs while respecting certain constraints, e.g. minimum service levels.

Apart from the aforementioned models, in which remanufactured products are used to fulfil known demands, other papers have examined the scenario in which the decision to remanufacture is taken together with marketing decisions, e.g. the pricing structure determines the amount of remanufactured products that are sold, which in turn dictates the number of products to be remanufactured. Two examples of papers that address the decisions of pricing and quantity to remanufacture together are Ferrer and Swaminathan (2006) and Atasu, Sarvary, and Van Wassenhove (2008). Table 2 illustrates the issues addressed on testing and remanufacturing.

Table 2. Summary of the selected literature on testing & remanufacturing decisions and inventory control in the context of remanufacturing operations.

Question	Methodology	Literature
Given a multi-period production horizon, when and how many returned products must be remanufactured to fulfil a certain demand?	Mathematical modelling	Van der Laan et al. (1999), DeCroix, Song, and Zipkin (2005), DeCroix and Zipkin (2005)
How many products to remanufacture? What is the optimal pricing strategy and, as a result, the optimal number of products to be remanufactured?	Mathematical modelling	Ferrer and Swaminathan (2006) and Atasu, Sarvary, and Van Wassenhove (2008).

2.2.3. *Marketing*

Only a handful paper have been devoted to the marketing of remanufactured products and there has been calls for more studies in this area (and in particular for more empirical papers). One topic that has begun receiving attention in the literature is the effect of remanufactured products on the sales of their new counterparts, i.e. cannibalisation effect. In a pioneer work, Guide and Li (2010) used a field research approach to empirically examine cannibalisation, and observed that cannibalisation is moderated by product type. Another important issue is the effect that marketing remanufactured products has on the desirability of their new counterparts. Past research has drawn attention to the fact that, unsurprisingly, malfunctioning or poorly re-worked remanufactured items could potentially damage manufacturers' reputation, even in cases where the manufacturer is

entirely uninvolved in the remanufacturing process (Atasu, Guide, and Van Wassenhove 2010).

Table 3. Summary of the literature on Marketing of reused products.

Question	Methodology	Literature
What is the optimal pricing strategy for new and remanufactured products?	Mathematical modelling	Ferrer and Swaminathan (2006), Atasu, Sarvary, and Van Wassenhove (2008)
What is the optimal pricing strategy for remanufactured products?	Mathematical modelling	Guide, Teunter, and Van Wassenhove (2003), Bakal and Akcali (2006), Mitra (2007) and Ovchinnikov (2011)
To what extent does the introduction of a new line of remanufactured products affect the sales of their new counterparts?	Field Study	Guide and Li (2010)
What affects the prices of remanufactured products?	Controlled lab experiment and real purchase analyses	Subramanian and Subramanyam (2012)

Other papers in this same stream of research have focused on how to optimally price new, remanufactured products or both. Atasu, Sarvary, and Van Wassenhove (2008) showed that optimally pricing re-manufactured products can substantially improve profitability and increase market share, while Ovchinnikov (2011) challenged the assumptions hitherto used to model supply and demand for new and remanufactured products, and argued that an inverted-U-shaped demand curve represents the relationships between price and volume of sales better than the more commonly used linear function. Although addressing pricing strategies issues in different contexts, e.g. OEMs pricing new and remanufactured products or independent manufacturers pricing remanufactured products, these papers have one characteristic in common - they all aim at finding solutions that maximise the overall profit using mathematical modelling as a tool.

3. Data collection

In this section we describe how the data collection for this paper has been carried out. In Section 3.1., we describe the archival data collection and in Section 3.2. we describe the interviews carried out in this study. It is worth highlighting that the data obtained by the archival collection, together with the information gathered in our interviews, underpins the characterisation and classification of NSCs for product recovery, i.e. Section 4. The insights obtained in the interviews alone are used in Section 6 to propose new avenues of research.

3.1. Archival data collection

The archival data collection was carried out online. We began by investigating the first fifty results that resulted from the query: “donate PC”³. We restricted our research to websites in English to avoid potential interpretation problems resulting from languages unfamiliar to the authors.⁴

In a second step, we manually examined each result from the initial list and attempted to trace the entire recovery supply chain. Note that our search was not limited to the initial list, as we have also searched for information contained in other webpages linked to that initial list, as well as other related pages.

In many cases, a substantial part of the information on the supply chain was not found, e.g. information on donors and recyclers. These observations were discarded. In 22 cases, however, the most relevant pieces of information on the supply chain were found online, and these observations constituted our final dataset.

There are limitations to this approach. First, we observed only a sample of the websites available online. Second, it is reasonable to assume that our sample may be more representative of medium and large organisations, small not-for-profit organisations being less likely to have a website. Third, by using this method, one can only observe information that these organisations wish to make public.

3.2. *Semi-structured interviews*

The second part of the data collection consisted of a series of semi-structured interviews with members of organisations engaged in NSCs. The use of semi-structured interviews is mainstream in business research (Lewis 1998; Myers and Newman 2007; Noor 2008). They were used for the following reasons. First, to triangulate our findings, an approach deemed as desirable when carrying out empirical research. For one, it lowers the risks of biased findings (Lewis 1998; Boyer and Swink 2008). Second, that the insights obtained in the interviews were used to propose new venues of research and new research questions, as presented in Section 5.

In total, 7 people from 7 different organisations agreed to be interviewed. We also drew on previous discussions with one of the NGOs in the United Kingdom that remanufacture computers (although for this particular case we did not tape the interview. Moreover, unlike the other ones interviewed, this organisation did remanufacture products other than computers. In fact, personal computers was only a small part of their business). All interviews were carried out by phone. A summary of the information on the interviews can be found in Table 4.

Table 4. Summary of the information on the interviewees

job title	destination
project coordinator	use in digital inclusion projects
project coordinator	use in digital inclusion projects
director of community partnerships	used in digital inclusion projects
director	e-waste watchdog
director	refurbish and re-sell computers
manager	match donors with donees
manager	match donors with donees
CEO	re-sell

4. Characterisation of NSCs

In this section we review the main characteristics of NSCs for computer recovery. This information is used in the subsequent section to compare profit and not-for-profit recovery supply chains, and to propose new questions that are relevant to NSCs.

We observe that NSCs are very complex in terms of players and the activities they carry out. In this section we characterise the different supply chains observed.

4.1. *NSCs: Core acquisition*

With respect to core acquisition, we have found that obtaining a good flow of high quality core may be challenging for profit and non-profit organisations alike. Prior research has

indicated that was the case for for-profit organisations, and that seems to be also the case for not-for-profit ones, as it has emerged from the interviews. Moreover, different levels of difficulty were documented across collectors.

The quotes below illustrate such differences. For one remanufacturer finding suitable core was not one of the main issues it faced:

“We had corporate partners that were donating computers every year. We were getting very good, very fast computers and the only fault they had were faulty hard drives.”

“Quite a few companies donate computers to us, more than 20, I don’t have the list here with me ... Every time they change their computers, they send me the computers being replaced”.

Others have experienced more difficulty in obtaining core:

“We don’t receive good computers. The ones we receive are simply bad (...) very old computers are easy to obtain because, as I said before, I am the person disposing their unwanted inventory.”

The difficulty in obtaining high-quality core may be partly explained by the mixed record that remanufacturing enjoy, or at least, by how they are perceived.⁵ While some believe that remanufacturing is good for the environment, others are sceptical. For this reason, we posit that manufacturers may be cautious when donating returned products, be it to non-for-profit or for-profit organisations. This last assertion, however, still needs empirical evidence.

“We know that many recyclers that claim to be sending used electronics to developing nations to bridge the digital divide, are really dumping non-working, non-fixable products (or too obsolete) on these countries, where they will never be reused ”

With respect to the differences, the main differences between for profit and not-for-profit supply chains are related to the direct economic incentive offered for core acquisition. While for-profit organisations normally offer cash and price rebates for high quality core, NSCs offer no direct economic incentive to consumers, apart from tax breaks and the payment of recycling fees. This result is in line with the findings in Curran and Williams (2010)⁶.

“(...) Actually if individuals want to donate, we have been developing a scheme with (name of the NGO) that people can drop off individual computers to (name of the NGO) to be recycled ”

“In our website we have a link to donations, where we explain which types of equipment are needed, where it is going to be used, and how to donate”

4.2. NSCs: Testing & remanufacturing

Personal computers collected by not-for-profit organisations are commonly remanufactured in site, although in some cases for-profit organisations, such as OEMs or software companies, participate in these supply chains. Some of the interactions between not-for-profit and for-profit organisations do involve cash flows, e.g. OEMs purchasing core from a charity engaged in product collection. In other cases, they don’t. Table 5 shows the proportions of not-for-profit organisations involved in collection and remanufacturing (results based on archival data collection).

One difference observed was that the remanufacturing of personal computers is partly done by volunteers, which are a valuable workforce for not-for-profit organisations, but have the drawback of not working in pre-determined schedules. It has emerged from our interviews, for instance that:

Table 5. NSPC: Testing & remanufacturing decisions and inventory control.

remanufacturing engagement	no collection	collection only	collection & remanufacturing	others or unknown
Personal computers	2	5	14	1

Table 5 shows the engagement of NSCs in the collection, re-use and remanufacturing. ‘No collection’ refers to the scenario in which the not-for-profit organisation is not involved in the physical distribution of the product. In this case, it simply offers a platform in which donors and donees can find one another. ‘Collection only’ refers to the situation where the not-for-profit organisation is engaged in collection, but not in remanufacturing. ‘Collection & remanufacturing’ refers to the situation where computers are collected and remanufactured by not-for-profit organisations.

“yes, it (the number of volunteers) is dependent upon project, so it can vary widely. On any given week we will likely have maybe five volunteers, but when we do our collection events, sort of project that we can have as many as twenty or thirty volunteers helping us.”

Moreover, employing socially disadvantaged individuals in the process of remanufacturing was considered in some cases a goal in itself. One of the organisations interviewed, for instance, used the process of refurbishing computers as a way to train the long term unemployed for a potential work on IT.

“ We have the courses of social educator, courses of computer literacy for citizenship and the courses of computers maintenance”. (discussing the three objectives of the project)

“ They (computers) first come to the maintenance of computers course, where it is taught a trade to youngsters so that they can not only enter the job market, but also help to generate income while studying. This puts them in a position to increase their family income”.

4.3. NSCs: Marketing

Donated personal computers are either recycled or returned to the second hand market as re-used or refurbished equipment. Personal computers that are remanufactured have the following main destinations. One, they are donated to individuals. In this case, not-for-profit collectors/remanufacturers donate refurbished items to targeted groups, e.g. low-income families and the elderly in the UK. Two, they are donated to not-for-profit organisations. A significant number of the collector/remanufacturers investigated partner with other organisations and send them donated refurbished computers, e.g. schools in the developed and developing world, young leadership projects, digital literacy training centres. Three, they are sold to individuals. In this case, computers are either sold to individuals for a reduced price, e.g. job seekers in the UK, or sold at full price to fund other projects. Four, computers are sold to other not-for-profit organisations with a reduced priced. Five, they are used for projects within the organisation that has collected and refurbished them. Six, they are lent to other not-for-profit organisations, which is very similar to the donation, with the difference that by lending remanufacturers can ensure that the computers will return for proper disposal when they reach their second EoLs. Seven, computers are sold as core to OEMs. Eight, donors and donees of computers are matched electronically. Note that, as it is the case for for-profit supply chains, personal computers are also sent overseas to developing countries. Note that none of these alternatives are mutually exclusive, i.e. some organisation both sell and donate. Table 6 shows some data on the destination of donated computers.

It has also surfaced in our interviews that market segmentation is carried out with not only profit, but also the environment and social concerns in mind. It is also clear that organisations have to balance the needs of the planet and society, with the necessity to generate enough profit to keep them afloat. Our findings confirms previous findings of Curran and Williams (2010), which observed that almost half of the items (55%) that go into re-use are sold to those of low income.

Table 6. NSC: Marketing of personal computers.

Destination	local vs. abroad			sold vs. donated		
	local	abroad	NA	sold	donated	NA
In-house projects	1	0	0	0	1	0
Other not-for-profit organisations	9	2	0	4	4	3
Market (revenue reverted to NGO)	2	0	0	2	0	0
Market (revenue donated)	0	0	0	0	0	0
Targeted individuals	2	0	0	2	0	0
Anyone (Match donors with donees)	2	0	0	0	2	0
Sell as core	1	0	0	1	0	0
NA	0	0	3	0	0	3
Total	17	2	3	9	7	6

Note: Table 6 shows the destination of donated personal computers. These are the figures obtained in our archival data collection. In-house projects refer to the use of remanufactured computers in projects ran by the organisation itself, e.g. digital literacy projects; Other not-for-profit organisation refer to remanufacturing of computers to be sold or donated to other not-for-profits, e.g. schools, hospitals; Market (revenue reverted to NGO) denotes the sale of computers to the general public where the revenues are reverted to the NGO, i.e. the NGO collecting and remanufacturing sells the remanufactured computers to anyone interested; Market (revenue donated) is similar to Market (revenue reverted to NGO), but the revenues accrued from the sales are donated; Targeted individuals refers to the sale or donation to targeted individuals, e.g. homeless, elderly; Sell as core refers to the activity of collecting computers and selling them as core.

“(...) But also the evaluation of project (name of the project) shows that actually sometimes making something entirely free is not the best route to go.”

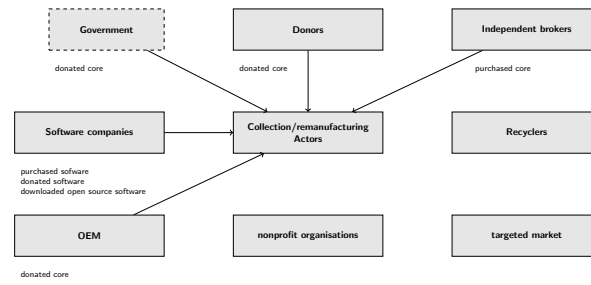
“(...) We want to try to make sure that we give it to the people that would benefit, so job seekers, families with low income, older people with fixed income, who are digitally excluded at the moment.”

“Everybody wanted whatever they could get their hands on. If it was something that we could do for 175 USD, people tried to ask if we could do for 125 USD. And we are paying American labor, American wages, and American benefits, and health care and all that, so we just don’t have that window room.”

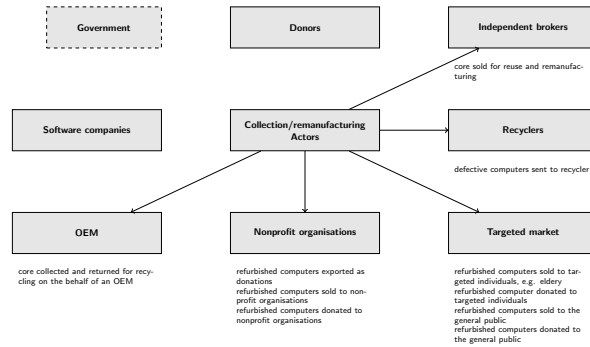
The main difference between NSCs and for-profit supply chains lies in the fact that for NSCs profit alone did not drive the final destination of the product refurbished. Some of the interviewees, for instance, stated that they try to allocate the collected computers to create as much social benefit as possible without neglecting the potential impact on the environment. The question of how to best allocate refurbished machines with social and environmental considerations in mind was alluded to in our interviews a number of times, although a definite answer as to how that could be achieved was not clarified.

4.4. *Summary of cash and material flows in NSCs*

Apart from examining how NSCs differ from for-profit supply chains, we have also mapped the flows of material and cash that occur between the many actors that take part in such supply chains. Figures 1 and 2 show a detailed picture of NSC for personal computers recovery, based on interviews and archival data research. Note that we do not claim that the framework presented in these two figures contains all existing relationships between the many parts that compose supply chains for product recovery - rather, it reports the relationships and flows of materials and cash observed in our study. Due to the large number of cases investigated, however, we believe this framework provides a good description of how NSC are organised.

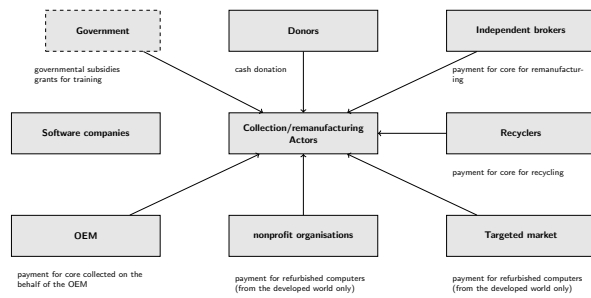


(a) Inbound flow

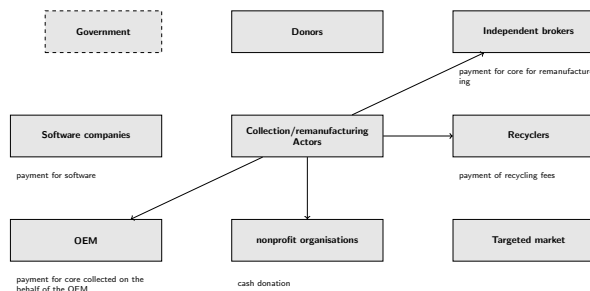


(b) Outbound flow

Figure 1. On the top of the figure: Material flows from actors to the collector/remanufacturer. On bottom: Material flows from the collection/remanufacturer to other actors.



(a) Inbound flow



(b) Outbound flow

Figure 2. On the top of the figure: Cash flows from actors to the collector/remanufacturer. On the bottom: Cash flows from the collection/remanufacturer to other actors.

5. Discussion and managerial implications

The main findings concerning product acquisition is that, in contrast to for-profit supply chains, core is not commonly purchased, and that most of the organisations we interviewed relied on donations. Thus, the managerial question that matters for them most is not how much to pay for core, but how to optimally allocate (limited) resources to obtain it. This involves the crucial decision as to where resources, in this case people, should be allocated: finding potential donors, nurturing existing relationships, prioritising certain collection strategies (capacity for collection being limited, these organisations need to prioritise the collection where the expected outcome is greater), improving the quality of their websites to foster collection, choosing the types of events to be organised to collect products, locating collection points, to name just a few. Each of such decisions needs to be optimised in order to obtain core that is at the same time of good quality and in the necessary quantity. Also surfaced from the interviews was that not-for-profit organisations do not have any framework to help them to make decisions on core acquisition. Managers need to pay close attention to how the resources to obtain core are allocated. Unfortunately, to the best of our knowledge, a good number of the aforementioned decisions have not been addressed in prior research, so managers could draw only on limited empirical evidence to guide their decisions.

With regard to the testing and remanufacturing, two main differences were uncovered. First, in some cases the workforce was composed by volunteers, who one may assume demand a much less strict schedule, if compared to regular employees. This has implications for the entire remanufacturing operation, as it adds an extra layer of uncertainty to the entire remanufacturing process. In other words, production planning has to accommodate the fact that the number of workers may vary from one day to another. Second, the workforce was viewed not only as a resource. For some of the not-for-profit organisations we interviewed, as important as recycling and remanufacturing products was the training of the personnel. One important question that managers need to consider carefully is how to allocate the existing working places. Short employment contracts, for example, can be preferable from the social viewpoint of training as a way to prepare as many out-of-work individual as possible. This, however, needs to be done considering that a high rotation of employees may be detrimental to the overall operations (empirical evidence nonexistent, more research is needed on this issue). To this point, little is known as to what is the optimal rotation of trainable workforce to, at the same time, maximise the value of the training obtained, keeping acceptable operational levels, nor what the minimum number of hours trained

Lastly, concerning how these products are marketed, we found that not-for-profit organisations commonly consider the triple bottom line. It is unclear, however, in which way environmental and social gains are compared and how these two objectives were (and should be) traded-off against each other and the capacity of the not-for-profit organisation to make a operate and make a profit. This seems a very important question to practitioners in the field and academic alike, which has not received, in our view, enough attention.

6. Main Challenges and Future Research Needed for NSCs

As previously mentioned in this paper, some of the issues not-for-profit companies face, have not been systematically addressed in prior research. In this section, based on the particular characteristics of NSCs discussed in Section 4, we propose new avenues for research. The research questions were drawn mostly on the discussions with practitioners,

i.e. interviews). To do so, first we summarise the differences between NSCs and for-profit supply chains described in the previous chapter.

6.1. *Main differences and similarities between NSC and for profit recovery supply chains*

In this section we synthesise, based on the information presented in Sections 4.1 to 4.5. and in conjunction with the review of the relevant literature, the main differences between for-profit and NSCs. We also point out to the gaps in the literature that arise from such differences (for more information on the relevant literature, we refer the reader to sections 3 and 4), which are translated into the research questions presented in Table 7.

Table 7. Table 7. Open questions that are relevant to NGOs engaged in remanufacturing.

Phase	Questions	NSCs (dissimilarities)	Sub-questions	Empirical modelling Empirical	vs.
Core Acquisition	R1. How to maximise the quality and volume of the donations of personal computers when no direct incentives are offered?	In NSCs, the main sources of core are donations from individuals, companies and governments. There are less direct financial incentives offered for core.	R.1.1 What are the company (donor) specific determinants, e.g. size, industry, effecting the quality of the computers donated to not-for-profit organisations?	Empirical	
			R1.2 What are the company (donor) specific determinants moderating the likelihood of a donation?	Empirical	
			R1.3 How to estimate the number and the quality of computers that can be collected in a given collection event and what factors, e.g. location and type of the venue used, socio-economic characteristics of the neighbourhood where the event takes place, affect its outcome?	Empirical	
			R1.4 What initiatives should be undertaken, e.g. carrying out collection events, contacting new potential donors, given limited resources, e.g. volunteers' and employees' time, in order to maximise the collection of high value items?	Empirical	and modelling
			R.1.5. How to manage relationships with existing partners to maintain/increase the number of donations?	Empirical	
Testing and re-manufacturing	R2. How to optimally manage remanufacturing assuming a fluctuating working force and considering employment as a goal?	Workforce is sometimes composed of volunteers, and can therefore fluctuate considerably. Unlike for-profit supply chains, employment of the workforce is sometimes both a resource and an objective in its own merit.	R2.1 How to control inventory when not only return times but also manufacturing resources (e.g. volunteers) are non-deterministic?	Modelling	
			R2.2. What is the optimal time the long-term unemployed should stay in training considering both their chances for employment after training and the overall effectiveness of the recovery operations?	Modelling	and empirical
			R2.3. In the context of employment in product take-back, how does the employability of a certain employee change as a function of the time he/she spends on training?	Empirical	
Marketing	R3. How to market remanufactured personal computers with economic, social and environmental considerations in mind?	Unlike for-profit supply chains, market segmentation is based on the maximisation of the social impact created by reusing computers.	3.1. What are the social benefits and environmental impacts associated with the donation of personal computers to organisations in developed and developing countries?	Empirical	
			3.2 Which organisations, e.g. schools, hospitals, if any, located in the developed and developing world should receive remanufactured computers considering the social benefits accrued from and the environmental impact caused by these donations?	Empirical Modelling	&
			3.3. What are the social benefits and environmental impacts associated with the donation of personal computers to users in the developed and developing countries?	Empirical	
			3.4 Which groups, e.g. jobless, elderly, general practitioners (GPs) in developing countries, should receive remanufactured computers considering the social benefits accrued from and the environmental impact associated with such donation?	Empirical Modelling	&

Note: Table 7 introduce some of the open questions in the emerging field of NSCs

7. Conclusion

In this paper we discuss the current industry practices and research needs concerning not-for-profit recovery supply chains, with a focus on personal computers. We find that in a number of aspects, NSCs resemble for-profit supply chains for products recovery.

In others, however, they are inherently distinct - given the nature and objectives of NSCs, the decisions on core acquisition, testing and remanufacturing, and marketing differ from those of for-profit supply chain. In line with what was observed in Curran and Williams (2010) our main findings are as follows. The main differences are: core in NSCs is mostly donated, rendering the research carried out on the pricing of core not applicable for some cases of NSCs. Concerning the remanufacturing process itself, the transformation of the labour force was perceived as an objective. Lastly, placement of the final remanufactured products varied across the cases investigated, and was not driven solely by profit.

Furthermore, based on the contrast between what was observed and the extant literature, we argue that NSCs have not received the attention they deserve, which is unfortunate. The implications for managers of our poor understanding on such supply chains are discussed. In summary, managers can hardly make evidence based decisions for some of the recovery issues that are most relevant to them, as research has been heavily centred on for-profit supply chains in detriment of NSCs.

We also outline new research opportunities on NSCs that have not been addressed in literature because, to a certain extent, they are pertinent to NSCs only. Furthermore, we propose a set of questions that we believe are relevant to these supply chains and are yet to be addressed. We think that a better understanding of these questions can provide guidance and improve decision making in not-for-profit supply chains.

As a limitation of our work, we must acknowledge that NSCs for computers can be dissimilar to the NSCs of other products, and some of the research needs described in this paper, which is concerned with the supply chains for personal computers only, may be product-specific and thus not generalisable to other products, e.g. avoiding the donation of below specification items is a major problem for personal computers, but may not be for other products, where recycling is proportionally more profitable.

Notes

¹For a review on the critical role that of collaboration between these players, we refer the reader to Jayaraman, Ross, and Agarwal (2008)

²The collector influences all three phases that constitute a supply chain for product recovery: product acquisition, testing/remanufacturing and marketing.

³We have used *Google* for the searches.

⁴To triangulate, and to increase the validity of our results to other parts of the world, we repeated the same research in German (query: “computer spenden”). We initially believed that the results for German-speaking countries would differ from those of English speaking countries (we believed that donating PCs was, for instance, more ubiquitous in the UK than in Germany), an intuition that has not been fully supported by our analyses. The results on the German market were not included in the discussions of this paper

⁵It is worth saying that this is necessarily not a view shared by the authors. We are just reporting the fact that some organisations do not see remanufacturing as an environmentally friendly initiative.

⁶It is worth mentioning that Curran and Williams (2010) focuses on furniture, electrical and IT appliances, as opposed to computers only.

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